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Application :	10/076269	Examiner :	PHAM	GAU :	2834
From:	OLA/CP	Location:	IDC FMF FDC	Date:	6-10-05
		Tracking #:	06102611	Week Date:	05-09-05

DOC CODE	DOC DATE	MISCELLANEOUS
☑ 1449	10/21/04	☐ Continuing Data
☐ IDS		☐ Foreign Priority
☐ CLM		☐ Document Legibility
☐ IIFW		☐ Fees
☐ SRFW		☐ Other
☐ DRW		
☐ OATH		
☐ 312		
☑ SPEC	12-19-02	

[RUSH] **MESSAGE:** (1) PTO-1449: Please provide date in "Foreign Patent Documents" section; Month and year are required for publication. If they are not available, please line through citation.

(2) Specification pages 1, 2, 4, 5, 7, 9, 10, 11 & 12 has lines on the left side of text. Please provide copy with no lines. Thank you.
OLA

[XRUSH] **RESPONSE:** Corrected

John Fitzpatrick-
~~James Oliff~~ 703-836-6400 **INITIALS:** RS

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REV 10/04

111987

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6/21

10/076,269

Sheet 1 of 1

Form PTO-1449 (REV. 8-83) US Dept. of Commerce PATENT & TRADEMARK OFFICE INFORMATION DISCLOSURE STATEMENT (Use several sheets if necessary)	ATTY DOCKET NO. 111987	APPLICATION NO. 10/076,269
	APPLICANT(S) Atsushi UMEDA	
	FILING DATE February 19, 2002	GROUP 2834

U.S. PATENT DOCUMENTS

EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUB CLASS

FOREIGN PATENT DOCUMENTS

		DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUB CLASS
U	A	JP-B-148045	3/3/2000			
U	B	JP 2000-69729	3/3/2000	Japan w/Abstract and Computer-translation		

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, etc.)

EXAMINER Ledaphan	DATE CONSIDERED 10/15/04

Examiner: Initial if citation considered, whether or not citation is in conformance with M.P.E.P. 609; draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

Date: June 24, 2004

ROTARY ELECTRIC MACHINE HAVING PARTIALLY Δ-CONNECTED STATOR WINDING

CROSS REFERENCE TO RELATED APPLICATION

This application is based on and incorporates herein by reference Japanese Patent Application No. 2001-84685 filed on March 23, 2001.

FIELD OF THE INVENTION

The present invention relates to a rotary electric machine such as an alternator mounted in a passenger vehicle, a truck or the like.

BACKGROUND OF THE INVENTION

A vehicular alternator (alternating current generator) is required to be small-sized and capable of supplying required power in low-speed rotations or high-speed rotations. The number of turns of a stator winding of a vehicular alternator is changed to meet such needs. However, when only the number of turns (T) of the stator windings is changed in a conventional vehicular alternator 1 having a Y-connected stator winding 23 and a rectifier device 5 as shown in Fig. 12, the output characteristics of the alternator changes as shown in Fig. 13. In Fig. 13, respective characteristic curves A, B and C show the output characteristic of the vehicular alternator when the number of turns (T) of the stator winding 23 is set to 3, 4 and 5. As the number of turns is changed from one integer number

of turns to another integer number of turns, the output characteristic is stepwisely changed. Therefore, a desired output characteristic cannot be achieved.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a rotary electric machine capable of changing its output characteristics more smoothly.

According to the present invention, a rotary electric machine has a multi-phase winding comprising a plurality of phase windings wound in a plurality of slots of a stator core at predetermined intervals. The multi-phase winding is formed by cyclically connecting one end of one phase winding to a middle point other than both ends of another phase winding. Thus, the phase windings form both the Δ-connection and the Y-connection in the stator winding arrangement. The windings connected in Δ-connection are substantially equivalent to windings connected in Y-connection having a number of turns multiplied by $1/\sqrt{3}$. Therefore, the number of turns of the multi-phase winding in conversion with that of Y-connection is equivalent to the number of turns of Y-connection portion added with a number of turns produced by multiplying a number of turns of theΔ-connection portion by $1/\sqrt{3}$. Therefore, by only changing a position of the middle point connected with two of the phase windings, a ratio of number of turns of the Y-connection portion to the Δ-connection portion can be changed at small intervals.

Particularly, in changing the ratio, only the position

Fig. 9 is a wiring diagram showing a vehicular alternator using two sets of three-phase windings having a phase difference of $\pi/6$ in electric angle according to a modification of the embodiment;

Fig. 10 is a wiring diagram showing a stator winding using two kinds of phase windings having a phase difference of $\pi/6$ in electric angle according to another modified embodiment;

Fig. 11 is a wiring diagram showing a stator winding using two kinds of phase windings having a phase difference of $\pi/6$ in electric angle according to a further modified embodiment;

Fig. 12 is a wiring diagram showing a conventional vehicular alternator; and

Fig. 13 is a graph showing an output characteristic of the conventional vehicular alternator.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to Fig. 1, a vehicular alternator 1 includes a stator 2, a rotor 3, a frame 4, a rectifier device 5 and the like.

The stator 2 includes a stator core 22, a stator winding 23 mounted on the stator core 22, and an insulator 24 for electrically insulating the stator core 22 from the stator winding 23. The stator core 22 is constituted by stacking thin steel plates and formed with a plurality of slots on a peripheral side of a shape of a circular ring.

The rotor 3 is rotatable integrally with a shaft 6 and

includes a Lundell-type pole core 7, a field winding 8, slip rings 9 and 10, a mixed flow fan 11 and a centrifugal fan 12 for cooling and the like. The shaft 6 is connected to a pulley 20 and is driven to rotate by an engine (not illustrated) mounted to a vehicle.

The frame 4 contains the stator 2 and the rotor 3, supports the rotor 3 in a rotatable state about the shaft 6 and is fixed with the stator 2 arranged on an outer peripheral side of the pole core 7 of the rotor 3 with a predetermined clearance therebetween. The frame 4 comprises a front frame 4A and a rear frame 4B, which are fastened by a plurality of fastening bolts 43 to thereby support the stator 2 and the like. The rectifier device 5 is connected with lead wires extended from the stator windings 23 for subjecting three-phase alternating current voltages applied from the stator windings 23 to three-phase full-wave rectification to convert into direct current voltage.

According to the vehicular alternator 1 having the above structure, when rotational force is transmitted from the engine (not illustrated) to the pulley 20 via a belt or the like, the rotor 3 is rotated in a predetermined direction. By applying excitation voltage from outside to the field winding 8 of the rotor 3 under the state, the respective claw-like magnetic pole portions of the pole core 7 are excited, three-phase alternating current voltages can be generated at the stator windings 23 and predetermined direct current power is outputted from an output terminal of the rectifier device 5.

The vehicular alternator 1 is wound with three-phase

the middle point 23C of the phase winding of X-phase and the winding finish end 23B of the phase winding of Y-phase are connected. Similarly, the middle point 23C of the phase winding of Y-phase and the winding finish end 23B of the phase winding of Z-phase are connected. The middle point 23C of the phase winding of Z-phase and the winding finish end 23B of the phase winding of X-phase are connected. That is, the middle point of each phase winding is connected to the winding finish end of another phase winding cyclically, in the clockwise direction in Fig. 2.

Further, according to the respective phase winding, the position of the middle point 23C is set such that in the series conductor number "64", "48" is constituted by from the winding start end 23A to the middle point 23C and "16" is constituted by from the middle point 23C to the winding finish end 23B. After the above connection has been carried out, lead wires extended from the winding start ends 23A of the respective phase windings are connected to the rectifier device 5.

The stator winding 23 is constructed as shown in Fig. 3 and arranged in the stator 22 as shown in Figs. 4-7.

The stator winding 23 mounted in the slot 25 of the stator core 22 is constituted by a plurality of electric conductors and the respective slot 25 contains an even number (4 pieces according to the embodiment) of electric conductors. Further, 4 electric conductors in the single slot 25 are aligned in one row in an order of an inner end layer, an inner middle layer, an outer middle layer and an outer end layer from an inner

electric conductor 232b of the outer middle layer and the electric conductor 232a of the inner middle layer, a middle layer coil end is formed. By connecting the electric conductor 231b of the outer end layer and the electric conductor 231a of the inner end layer, an end layer coil end is formed.

Meanwhile, the electric conductor 232a of the inner middle layer at inside of one slot 25 is also paired with an electric conductor 231a′ of an inner end layer at inside of other slot 25 of the stator core 22 remote from the electric conductor 232a by one magnetic pole pitch in the clockwise direction. Similarly, an electric conductor 231b′ of an outer end layer at inside of one slot 25 is also paired with the electric conductor 232b of the outer middle layer at inside of other slot 25 of the stator core 22 remote from the electric conductor 231b′ by one magnetic pole pitch in the clockwise direction. Further, these electric conductors are connected on other end face side in the axial direction of the stator core 22.

Therefore, on the other axial end face side of the stator core 22, as shown in Fig. 6, there are arranged an outer side joint portion 233b for connecting the electric conductor 231b′ of the outer end layer and the electric conductor 232b of the outer middle layer, and an inner side joint portion 233a for connecting the electric conductor 231a′ of the inner end layer and the electric conductor 232a of the inner middle layer in a state of being shifted from each other in a diameter direction and a peripheral direction. By connecting the electric conductor 231b′ of the outer end layer and the electric conductor

232b of the outer middle layer and connecting the electric conductor 231a′ of the inner end layer and the electric conductor 232a of the inner middle layer, there are formed two continuous layer coil ends arranged on different concentric circles.

Further, as shown in Fig. 3, the electric conductor 231a of the inner end layer and the electric conductor 231b of the outer end layer are provided by a large segment 231 constituted by forming a series of the electric conductors substantially in a U-like shape. Further, the electric conductor 232a of the inner middle layer and the electric conductor 232b of the outer middle layer are provided by a small segment 232 constituted by forming a series of the electric conductors substantially in the U-like shape. A conductor segment 230 in the U-like shape constituting a base unit is formed with the large segment 231 and the small segment 232.

The respective segments 231 and 232 are provided with portions contained at inside of the slot 25 and extended along the axial direction and slanted portions 231f, 231g, 232f and 232g as bent portions extended to incline by predetermined angles relative to the axial direction. By the slanted portions, there are formed a group of coil ends projected from the stator core 22 to the both end faces in the axial direction. Flow paths of cooling wind produced when the mixed flow fan 11 and the centrifugal fan 12 attached to both end faces in the axial direction of the rotor 3 are rotated are mainly formed among the slanted portions. Further, the flow paths of cooling wind are arranged also with lead wires of the stator winding 23.

The above construction is applied to the conductor segments 230 of all the slots 25. Further, in a group of coil ends on a nonturn portion side, an end portion 231e' of the outer end layer and an end portion 232e of the outer middle layer as well as an end portion 232d of the inner middle layer and an end portion 231d' of the inner end layer are joined respectively by means of welding, ultrasonic welding, arc welding, soldering or the like to thereby form the outer side joint portion 233b and the inner side joint portion 233a and electrically connected.

The stator winding 23 included in the stator 2 of the vehicular alternator 1 according to the embodiment is provided with a Δ-connection portion formed by using portions of the respective phase winding by cyclically connecting the middle point 23C of one phase winding and the winding finish end 23b of other phase winding for all the phase windings. As is well known, a line voltage generated at the Δ-connection portion becomes $1/\sqrt{3}$ (square root of 3) times as much as a line voltage generated at the Y-connection portion. That is, the Δ-connection portion is equivalent to the Y-connection portion of a series conductor number having a multiplication factor of $1/\sqrt{3}$.

Therefore, according to the embodiment, the series conductor number of the Δ-connection portion becomes 9.2 ($= 16 \times (1/\sqrt{3})$) pieces equivalently in conversion to that of the Y-connection. The Y-connection portion having the series conductor number of 48 is connected in series with the Δ-connection portion. Therefore, the series conductor number of a total of the stator winding 23, becomes 57.2 pieces equivalently

in conversion to that of the Y-connection. In this way, while the number of conductors at inside of the slot 25 stays to be 4 pieces for all the slots 25, the substantial series conductor number can be changed from 64 in the case of the conventional Y-connection which is not provided with the Δ-connection portion to 57.2 (in correspondence with 3.6 turns).

Fig. 8 is a graph showing an output characteristic of the vehicular alternator according to the embodiment. In this figure, characteristic curves A and B show output characteristics of the conventional vehicular alternator when the number of turns of the stator winding connected by Y-connection is set to 3 and 4. Characteristic curve D shows an output characteristic of the vehicular alternator 1 according to the embodiment in correspondence with 3.6 turns. In this way, according to the vehicular alternator 1 of the embodiment, there can be provided an intermediary output characteristic for smoothing stepwise output characteristics change provided in the case of using the stator winding having number of turns of integer values as in the conventional vehicular alternator.

Further, by changing the position of the middle point 23C of the respective phase windings included in the stator winding 23, a rate of respective series conductor numbers (number of turns) of the Δ-connection portion and the Y-connection portion, can arbitrarily be changed. Therefore, the substantial series conductor number in the case of being converted into Y-connection can arbitrarily be changed. That is, the respective phase windings included in the stator winding 23 are